2.0 Watershed Description and Source Assessment

In this section, the types of data available and information collected for the development of a TMDL for the bacteria impaired segments of the Upper York River, Lower Mattaponi and Lower Pamunkey watershed are presented. This information was used to characterize the estuary and its watershed and to inventory and characterize the potential point and nonpoint sources of bacteria in the watershed.

2.1 Data and Information Inventory

A wide range of data and information were used in the development of these TMDLs. Categories of data that were used include the following:

(1) Physiographic data that describe physical conditions (i.e., topography, soils, and land use) within the watershed

(2) Hydrographic data that describe physical conditions within the estuary, such as the estuary network and connectivity, and the estuary depth, width, slope, and elevation

(3) Data related to uses of the watershed and other activities in the basin that can be used in the identification of potential fecal coliform sources

(4) Environmental monitoring data that describe estuarine flow and water quality conditions in the estuary

Table 2-1 shows the various data types and the data sources used in the Upper York, Lower Mattaponi and Lower Pamunkey Rivers TMDL development.

Table 2- 1: Inventory of Data and Information Used in the TMDL Development

Data Category	Description	Source(s)
Watershed physiographic data	Watershed boundary	NRCS Watershed Boundary Dataset
	Land use/land cover	NLCD
	Soil data (*soil data mart*)	USGS
	Topographic data (USGS-30 meter DEM)	USGS
Hydrographic data	Stream network and reaches (RF3)	NHD
	Bathymetry Data	VA DEQ
Weather data	Information, data, reports, and maps that can be used to support fecal coliform source identification and loading	NCDC
Watershed activities/ uses data and information related to bacteria production	Livestock inventory	Census of Agriculture 2007
	Wildlife inventory	VA DGIF
	Septic systems inventory and failure rates	VA DEQ, Census Bureau
	Pet estimates	National pet estimates per household, U.S. Census Bureau, ACO
Point sources and direct discharge data and information	Permitted facilities locations and discharge monitoring reports (DMRs)	VA DEQ, EPA Permit Compliance System
Environmental monitoring data	Ambient instream monitoring data	VA DEQ, VDH-DSS
	Bacteria Source Tracking Data	VDH-DSS
	Stream flow data	USGS
	Tidal data	NOAA

Notes:
ACO: Animal Control Office
EPA: Environmental Protection Agency
NCDC: National Climatic Data Center
NHD: National Hydrography Dataset
NLCD: National Land Coverage Data
NOAA: National Oceanic and Atmospheric Association
NRCS: Natural Resources Conservation Service
RF3: EPA Reach File Version 3.0
USGS: U.S. Geological Survey
VDH-DSS: Virginia Department of Health - Department of Shellfish Sanitation
VA DEQ: Virginia Department of Environmental Quality
VA DGIF: Virginia Department of Game and Inland Fisheries

2.2 Watershed Description and Identification

The bacteria impaired segments and watersheds are located within the borders of King and Queen, New Kent and King William Counties. Within the watershed's boundaries is also the Town of West Point. As shown in **Figure 2-1**, the major roadways that run through the watershed are Routes 249, 273, 30 and 33, and Interstate 64. Route 249 runs from west to east through the middle of the watershed. Route 273 runs from south to north in the southern portion of the watershed. Route 30 runs from northwest to southeast in the middle portion of the watershed. Route 33 runs from east to west in the eastern portion of the watershed. Interstate 64 runs east-west outside the southwestern border of the watershed. The watershed has a drainage area of 106,392 acres.

Figure 2-2 presents the existing VA DEQ and VDH-DSS water quality stations located within the bacteria impairments and boundaries.

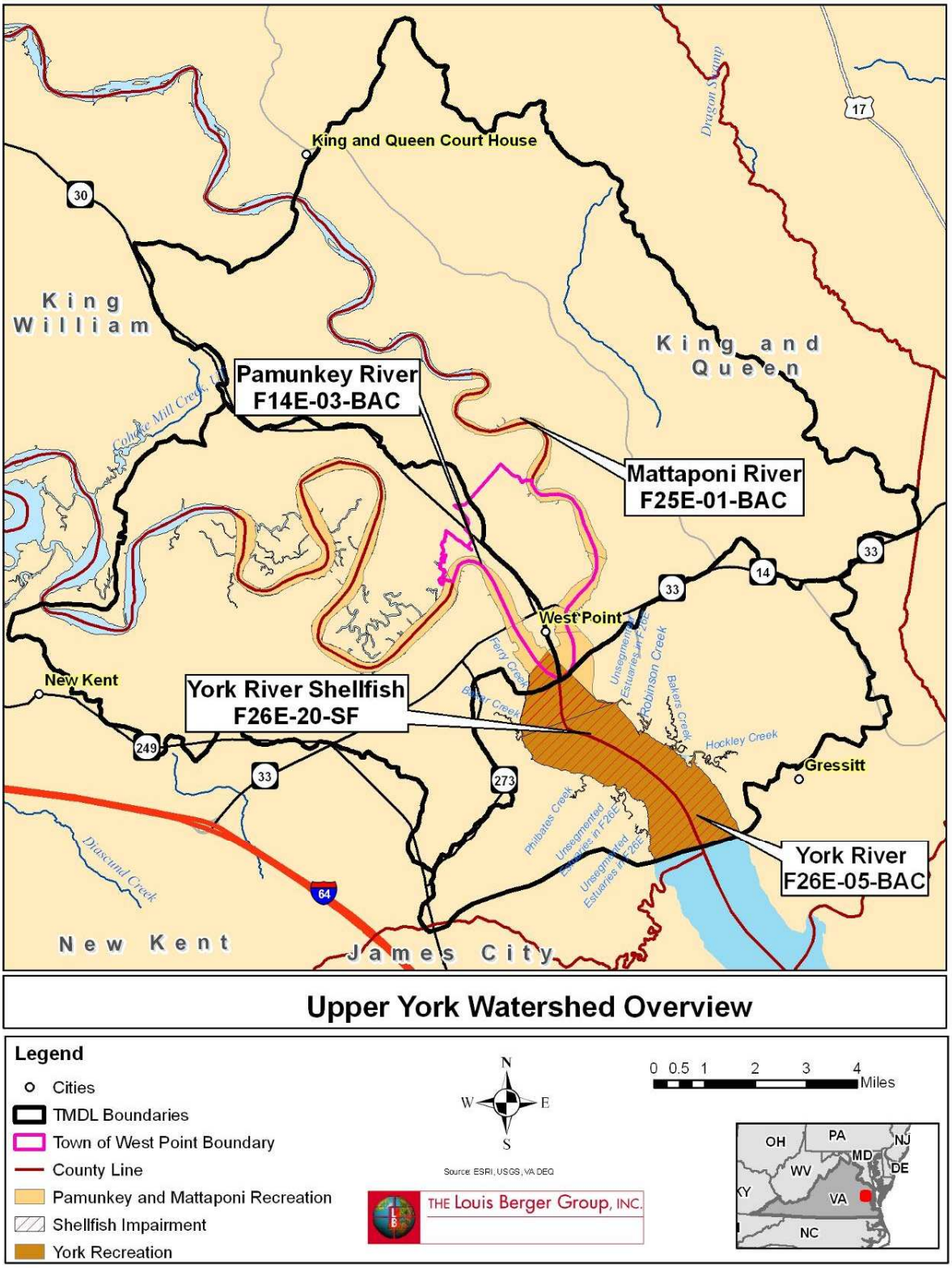

Figure 2-1: Overview Map of the Watersheds Draining into the Bacteria Impaired Segments and Water Quality Stations

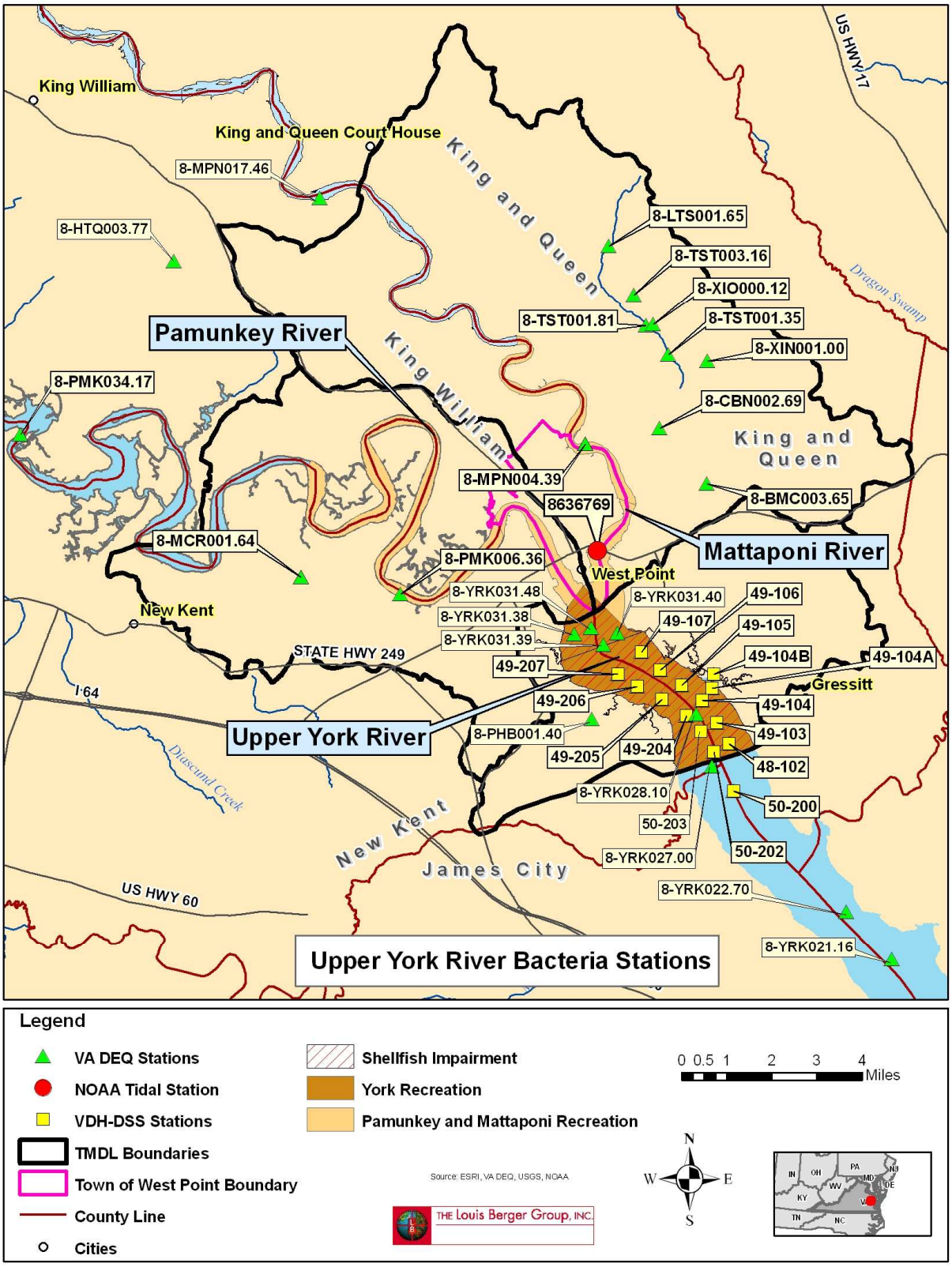

Figure 2-2: Upper Tidal York River watershed VA DEQ and VDH-DSS Bacteria Stations.

2.2.1 Topography

A digital elevation model (DEM) based on USGS National Elevation Dataset (NED) was used to characterize topography in the watershed. NED data were obtained from the National Map Seamless Data Distribution System maintained by the USGS Eros Data Center. Elevation within the TMDL watershed ranges from -5 to 55 feet above mean sea level.

2.2.2 Soils Types and Hydrologic Soil Groups

The following section details soil type and hydrologic group for each TMDL watershed. The soil type characterization is based on data obtained from *soil data mart*, a USGS-approved program that is a multi-purpose environmental analysis system integrating GIS, national watershed data, and environmental assessment and modeling tools.

The hydrologic soil groups are also based on data obtained from *soil data mart*. The hydrologic soil groups represent different levels of infiltration capacity of the soils. Hydrologic soil group "A" designates soils that are well- to excessively well-drained, whereas hydrologic soil group "D" designates soils that are poorly drained. This means that soils in hydrologic group "A" allow a larger portion of the rainfall to infiltrate and become part of the ground water system. On the other hand, compared to the soils in hydrologic group "A," soils in hydrologic group "D" allow a smaller portion of the rainfall to infiltrate and become part of the ground water. Consequently, more rainfall becomes part of the surface water runoff. Descriptions of the hydrologic soil groups are presented in **Table 2-2**. The term "not identified" in the hydrologic group breakdown refers to those classes defined as water, since water does not belong to any group.

Table 2- 2: Descriptions of Hydrologic Soil Groups

Hydrologic Soil Group	Description
A	High infiltration rates. Soils are deep, well-drained to excessively drained sand and gravels.
B	Moderate infiltration rates. Deep and moderately deep, moderately well- and well-drained soils with moderately coarse textures.
C	Moderate to slow infiltration rates. Soils with layers impeding downward movement of water or soils with moderately fine or fine textures.
C/D	Combination of Hydrologic Soil Groups C and D.
D	Very slow infiltration rates. Soils are clayey, have high water table, or shallow to an impervious cover.

2.2.2.1 Upper York River (TMDL #1 and TMDL #2)

There are 50 soil associations located in the watershed (**Table 2-3**). The dominant soil types within the watershed are Emporia (29%) and Nevarc (8.2%).

Table 2- 3: Soil Types within the Upper Tidal York River watershed

Soil Type	Total Acres	Percentage
Altavista	2,852	2.7
Augusta	544	0.5
Bama	475	0.4
Bibb	456	0.4
Bohicket	6,748	6.3
Bojac	1,651	1.6
Caroline	646	0.6
Catpoint	20	0.0
Conetoe	366	0.3
Craven	1,477	1.4
Daleville	978	0.9
Dogue	1,370	1.3
Dragston	12	0.0
Emporia	30,811	29.0
Eulonia	1,544	1.5
Eunola	232	0.2
Johnston	624	0.6
Kempsville	2,990	2.8
Kenansville	73	0.1
Kinston	1,505	1.4
Lanexa	1,124	1.1
Levy	553	0.5
Mattan	1,222	1.1
Mattaponi	18	0.0
Munden	460	0.4
Myatt	21	0.0
Nawney	28	0.0
Nevarc	8,732	8.2
Nimmo	6	0.0
Norfolk	7	0.0
Orangeburg	71	0.1
Pactolus	81	0.1
Pamunkey	695	0.7
Pits, gravel	96	0.1
Rappahannock	2,199	2.1

Table 2- 3: Soil Types within the Upper Tidal York River watershed		
Soil Type	**Total Acres**	**Percentage**
Remlik	2,905	2.7
Roanoke	2,074	1.9
Rumford	272	0.3
Seabrook	529	0.5
Slagle	6,960	6.5
State	2,836	2.7
Suffolk	1,017	1.0
Tarboro	948	0.9
Tetotum	3,579	3.4
Tomotley	1,564	1.5
Uchee	81	0.1
Udorthents	432	0.4
Wahee	518	0.5
Wehadkee	213	0.2
Wickham	128	0.1
TOTAL*	**94,743**	**100.0**
*The difference in the total and the watershed drainage area is the area of the watershed that is occupied by water. Water is not included as a soil type.		

The major hydrologic group within the Upper Tidal York River watershed is group C, with 56% of the watershed containing these soils. Soil group C is defined as having moderate to slow infiltration rates. Soils contain layers impeding downward movement of water or soils with moderately fine or fine textures. The second major hydrologic group within the watershed is group D, with 16% of the watershed containing these soils. Soil group D is defined as having very slow infiltration rates. Soils are clayey, have a high water table, as well as shallow to impervious cover. **Table 2-4** summarizes the total percentages of hydrologic groups for the Upper York River.

Table 2- 4: Hydrologic Groups Within the Upper Tidal York River watershed		
Hydrologic Soil Group	**Total Acres**	**Percentage of Watershed**
A	4,570	4
B	10,603	10
B/D	3,069	3
C	59,307	56
D	16,763	16
Not Identified	12,080	11
Total	**106,392**	**100**

2.2.2.2 Lower Pamunkey River (TMDL #3)

There are 44 soil associations located in the watershed (**Table 2-5**). The dominant soil types within the watershed are Nevarc (22.7%) and Bohicket (15.2%).

Table 2- 5: Soil Types within the Lower Pamunkey River Watershed

Soil Type	Total Acres	Percentage
Altavista	2,111	7.5%
Augusta	113	0.4%
Bama	357	1.3%
Bibb	89	0.3%
Bohicket	4,318	15.2%
Bojac	200	0.7%
Caroline	608	2.1%
Catpoint	1	0.0%
Conetoe	157	0.6%
Craven	462	1.6%
Daleville	74	0.3%
Dogue	973	3.4%
Dragston	11	0.0%
Emporia	312	1.1%
Eulonia	590	2.1%
Eunola	54	0.2%
Johnston	526	1.9%
Kempsville	1,713	6.0%
Kenansville	21	0.1%
Lanexa	1,095	3.9%
Mattan	1,023	3.6%
Munden	59	0.2%
Myatt	10	0.0%
Nawney	28	0.1%
Nevarc	6,426	22.7%
Nimmo	6	0.0%
Norfolk	7	0.0%
Orangeburg	71	0.3%
Pactolus	67	0.2%
Pamunkey	521	1.8%
Remlik	1,030	3.6%
Roanoke	1,073	3.8%

Table 2- 5: Soil Types within the Lower Pamunkey River Watershed		
Soil Type	**Total Acres**	**Percentage**
Seabrook	208	0.7%
Slagle	985	3.5%
State	896	3.2%
Suffolk	166	0.6%
Tarboro	118	0.4%
Tetotum	389	1.4%
Tomotley	479	1.7%
Uchee	13	0.0%
Udorthents	363	1.3%
Wahee	329	1.2%
Wehadkee	176	0.6%
Wickham	107	0.4%
TOTAL*	**28,337**	**100.0%**
*The difference in the total and the watershed drainage area is the area of the watershed that is occupied by water. Water is not included as a soil type.		

The major hydrologic group within the Lower Pamunkey River Watershed is group C, with 40.4% of the watershed containing these soils. Soil group C is defined as having moderate to slow infiltration rates. Soils contain layers impeding downward movement of water or soils with moderately fine or fine textures. The second major hydrologic group within the watershed is group D, with 26.7% of the watershed containing these soils. Soil group D is defined as having very slow infiltration rates. Soils are clayey, have a high water table, as well as shallow to impervious cover. **Table 2-6** summarizes the total percentages of hydrologic groups for the Lower Pamunkey River.

Table 2- 6: Hydrologic Groups Within the Lower Pamunkey River Watershed		
Hydrologic Soil Group	**Total Acres**	**Percentage of Watershed**
A	1,408	4.3%
B	4,097	12.5%
B/D	479	1.5%
C	13,243	40.4%
D	8,748	26.7%
Not Identified	4,819	14.7%
Total	**32,793**	**100.0%**

2.2.2.3 Lower Mattaponi River (TMDL #4)

There are 38 soil associations located in the watershed (**Table 2-7**). The dominant soil types within the watershed are Emporia (50.7%) and Slagle (8.8%).

Table 2-7: Soil Types within the Lower Mattaponi River Watershed

Soil Type	Total Acres	Percentage
Altavista	414	0.8%
Augusta	78	0.2%
Bama	118	0.2%
Bibb	366	0.7%
Bohicket	1,783	3.6%
Bojac	986	2.0%
Catpoint	17	0.0%
Conetoe	209	0.4%
Craven	885	1.8%
Daleville	903	1.8%
Emporia	25,076	50.7%
Eulonia	954	1.9%
Eunola	178	0.4%
Kempsville	510	1.0%
Kenansville	52	0.1%
Kinston	1,014	2.0%
Lanexa	29	0.1%
Levy	427	0.9%
Mattan	198	0.4%
Munden	285	0.6%
Myatt	11	0.0%
Pactolus	13	0.0%
Pits, gravel	96	0.2%
Rappahannock	1,598	3.2%
Remlik	1,875	3.8%
Roanoke	812	1.6%
Rumford	9	0.0%
Seabrook	319	0.6%
Slagle	4,374	8.8%
State	1,509	3.1%

Table 2-7: Soil Types within the Lower Mattaponi River Watershed		
Soil Type	**Total Acres**	**Percentage**
Suffolk	276	0.6%
Tarboro	782	1.6%
Tetotum	2,272	4.6%
Tomotley	829	1.7%
Udorthents	57	0.1%
Wahee	74	0.2%
Wehadkee	36	0.1%
Wickham	21	0.0%
TOTAL*	**49,447**	**100.0%**
*The difference in the total and the watershed drainage area is the area of the watershed that is occupied by water. Water is not included as a soil type.		

The major hydrologic group within the Lower Mattaponi River Watershed is group C, with 66.3% of the watershed containing these soils. Soil group C is defined as having moderate to slow infiltration rates. Soils contain layers impeding downward movement of water or soils with moderately fine or fine textures. The second major hydrologic group within the watershed is group D, with 12.0% of the watershed containing these soils. Soil group D is defined as having very slow infiltration rates. Soils are clayey, have a high water table, as well as shallow to impervious cover. **Table 2-8** summarizes the total percentages of hydrologic groups for the Lower Mattaponi River.

Table 2- 8: Hydrologic Groups Within the Lower Mattaponi River Watershed		
Hydrologic Soil Group	**Total Acres**	**Percentage of Watershed**
A	3,044	5.8%
B	3,714	7.1%
B/D	1,842	3.5%
C	34,551	66.3%
D	6,239	12.0%
Not Identified	2,747	5.3%
Total	**52,138**	100.0%

2.2.3 Land Use

The land use characterization for the Upper York TMDL watershed (TMDL #1 and TMDL #2) was based on the latest available land cover data from the National Land Cover Dataset, also known as NLCD 2005 Land Use Dataset. The distribution of land uses in the watershed, by land area and percentage, are presented in **Table 2-9**. Brief descriptions of land use classifications are presented in **Table 2-12**. Dominant land uses in the watershed are forest (44%) and wetlands (19%). **Figure 2-3** depicts the land use distribution within the Upper Tidal York River watershed.

Table 2- 9: Land Use within the Upper Tidal York River watershed

General Land Use Category	Specific Land Use Type	Acres	Total Acres	Percentage of Watershed	Total Percent
Developed	Developed Open Space	1,217	2,582	1%	2%
	High Intensity Developed	176		<1%	
	Medium Intensity Developed	296		<1%	
	Low Intensity Developed	892		1%	
Agriculture	Cultivated	11,820	15,743	11%	15%
	Pasture/Hay	3,923		4%	
Forest	Deciduous Forest	16,238	46,566	15%	44%
	Evergreen Forest	21,750		20%	
	Mixed Forest	8,578		8%	
Wetlands	Estuarine Emergent Wetland	9,372	20,658	9%	19%
	Estuarine Forested Wetland	4		<1%	
	Estuarine Scrub/Shrub Wetland	20		<1%	
	Palustrine Emergent Wetland	964		1%	
	Palustrine Forested Wetland	9,719		9%	
	Palustrine Scrub/Shrub Wetland	578		1%	
Water	Palustrine Aquatic Bed	9	11,285	<1%	11%
	Open Water	11,276		11%	
Other	Barren Land	32	9,558	<1%	9%
	Grassland	2,410		2%	
	Scrub/Shrub	7,112		7%	
	Unconsolidated Shore	4		<1%	
Total		**106,392**		**100%**	**100%**

The land use characterization for the Lower Pamunkey TMDL watershed (TMDL #3) was based on the latest available land cover data from the National Land Cover Dataset, also known as NLCD 2005 Land Use Dataset. The distribution of land uses in the watershed, by land area and percentage, are presented in **Table 2-10**. Brief descriptions of land use classifications are presented in **Table 2-12**. Dominant land uses in the watershed are forest (38%) and wetlands (27%). **Figure 2-3** depicts the land use distribution within the Lower Pamunkey River watershed.

Table 2-10: Land Use within the Lower Pamunkey River Watershed

General Land Use Category	Specific Land Use Type	Acres	Total Acres	Percentage of Watershed	Total Percent
Developed	Developed Open Space	339	978	1%	3%
	High Intensity Developed	125		<1%	
	Medium Intensity Developed	163		<1%	
	Low Intensity Developed	352		1%	
Agriculture	Cultivated	2,955	4,161	9%	13%
	Pasture/Hay	1,206		4%	
Forest	Deciduous Forest	4,997	12,410	15%	38%
	Evergreen Forest	4,106		13%	
	Mixed Forest	3,306		10%	
Wetlands	Estuarine Emergent Wetland	5,460	9,005	17%	27%
	Estuarine Forested Wetland	3		<1%	
	Estuarine Scrub/Shrub Wetland	8		<1%	
	Palustrine Emergent Wetland	125		<1%	
	Palustrine Forested Wetland	3,183		10%	
	Palustrine Scrub/Shrub Wetland	227		1%	
Water	Palustrine Aquatic Bed	5	4,284	<1%	13%
	Open Water	4,278		13%	
Other	Barren Land	28	1,955	<1%	6%
	Grassland	142		<1%	
	Scrub/Shrub	1,784		5%	
	Unconsolidated Shore	2		<1%	
Total		**32,793**		**100%**	**100%**

The land use characterization for the Lower Mattaponi TMDL watershed (TMDL #4) was based on the latest available land cover data from the National Land Cover Dataset, also known as NLCD 2005 Land Use Dataset. The distribution of land uses in the watershed, by land area and percentage, are presented in **Table 2-11**. Brief descriptions of land use classifications are presented in **Table 2-12**. Dominant land uses in the watershed are forest (49%) and wetlands (17%). **Figure 2-3** depicts the land use distribution within the Lower Mattaponi River watershed.

Table 2-11: Land Use within the Lower Mattaponi River Watershed

General Land Use Category	Specific Land Use Type	Acres	Total Acres	Percentage of Watershed	Total Percent
Developed	Developed Open Space	478	1,031	1%	2%
	High Intensity Developed	33		<1%	
	Medium Intensity Developed	92		<1%	
	Low Intensity Developed	428		1%	
Agriculture	Cultivated	6,186	8,254	12%	16%
	Pasture/Hay	2,068		4%	
Forest	Deciduous Forest	8,337	25,604	16%	49%
	Evergreen Forest	13,606		26%	
	Mixed Forest	3,662		7%	
Wetlands	Estuarine Emergent Wetland	2,755	8,740	5%	17%
	Estuarine Forested Wetland	2		<1%	
	Estuarine Scrub/Shrub Wetland	11		<1%	
	Palustrine Emergent Wetland	804		2%	
	Palustrine Forested Wetland	4,897		9%	
	Palustrine Scrub/Shrub Wetland	270		1%	
Water	Palustrine Aquatic Bed	3	2,440	<1%	5%
	Open Water	2,437		5%	
Other	Barren Land	3	6,069	<1%	12%
	Grassland	1,875		4%	
	Scrub/Shrub	4,189		8%	
	Unconsolidated Shore	2		<1%	
Total		**52,138**		**100%**	**100%**

Table 2-12: Descriptions of Land Use Types	
Land Use Type	**Description**
Open Water	All areas of open water, generally with less than 25 percent cover of vegetation or soil.
Estuarine Emergent Wetlands	Includes all tidal wetlands dominated by erect, rooted, herbaceous hydrophytes (excluding mosses and lichens). Wetlands that occur in tidal areas in which salinity due to ocean-derived salts is equal to or greater than 0.5 percent and that are present for most of the growing season in most years. Perennial plants usually dominate these wetlands. Total vegetation cover is greater than 80 percent.
Estuarine Scrub / Shrub Wetland	Includes all tidal wetlands dominated by woody vegetation less than 5 meters in height, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is equal to or greater than 0.5 percent. Total vegetation coverage is greater than 20 percent.
Estuarine Forested Wetland	Includes all tidal wetlands dominated by woody vegetation greater than or equal to 5 meters in height, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is equal to or greater than 0.5 percent. Total vegetation coverage is greater than 20 percent.
Palustrine Emergent Wetland	Includes all tidal and nontidal wetlands dominated by persistent emergent vascular plants, emergent mosses or lichens, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is below 0.5 percent. Plants generally remain standing until the next growing season. Total vegetation cover is greater than 80 percent.
Palustrine Forested Wetland	Includes all tidal and nontidal wetlands dominated by woody vegetation greater than or equal to 5 meters in height, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is below 0.5 percent. Total vegetation coverage is greater than 20 percent.
Palustrine Scrub/Shrub Wetland	Includes all tidal and non tidal wetlands dominated by woody vegetation less than 5 meters in height, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is below 0.5 percent. Total vegetation coverage is greater than 20 percent. The species present could be true shrubs, young trees and shrubs, or trees that are small or stunted due to environmental conditions (Cowardin et al. 1979).
Palustrine Aquatic Bed	Includes tidal and nontidal wetlands and deepwater habitats in which salinity due to ocean-derived salts is below 0.5 percent and which are dominated by plants that grow and form a continuous cover principally on or at the surface of the water. These include algal mats, detached floating mats, and rooted vascular plant assemblages. Total vegetation cover is greater than 80 percent.
Unconsolidated Shore	Unconsolidated material such as silt, sand, or gravel that is subject to inundation and redistribution due to the action of water. Characterized by substrates lacking vegetation except for pioneering plants that become established during brief periods when growing conditions are favorable. Erosion and deposition by waves and currents produce a number of landforms representing this class.
Developed, Open Space	Includes areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total cover.
Developed, Low Intensity	Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 21 to 49 percent of total cover.
Developed, Medium Intensity	Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50 to 79 percent of the total cover.
Developed, High Intensity	Includes highly developed areas where people reside or work in high numbers. Impervious surfaces account for 80 to 100 percent of the total cover.
Pasture/Hay	Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing

Table 2-12: Descriptions of Land Use Types	
Land Use Type	**Description**
	or the production of seed or hay crops, typically on a perennial cycle and not tilled. Pasture/hay vegetation accounts for greater than 20 percent of total vegetation.
Cultivated Crops	Areas used for the production of annual crops. Crop vegetation accounts for greater than 20 percent of total vegetation. This class also includes all land being actively tilled.
Barren Land (Rock/Sand/Clay)	Barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits, and other accumulations of earth material. Generally, vegetation accounts for less than 10 percent of total cover.
Deciduous Forest	Areas dominated by trees generally greater than 5 meters tall and greater than 20 percent of total vegetation cover. More than 75 percent of the tree species shed foliage simultaneously in response to seasonal change.
Evergreen Forest	Areas dominated by trees generally greater than 5 meters tall and greater than 20 percent of total vegetation cover. More than 75 percent of the tree species maintain their leaves all year. Canopy is never without green foliage.
Mixed Forest	Areas dominated by trees generally greater than 5 meters tall, and greater than 20 percent of total vegetation cover. Neither deciduous nor evergreen species are greater than 75 percent of total tree cover.
Grassland	Areas dominated by grammanoid or herbaceous vegetation, generally greater than 80 percent of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.
Scrub/Shrub	Areas dominated by shrubs less than 5 meters tall with shrub canopy typically greater than 20 percent of total vegetation. This class includes tree shrubs, young trees in an early successional stage, or trees stunted from environmental conditions.
Source: Coastal NLCD Classification Scheme, NOAA Coastal Services Center	

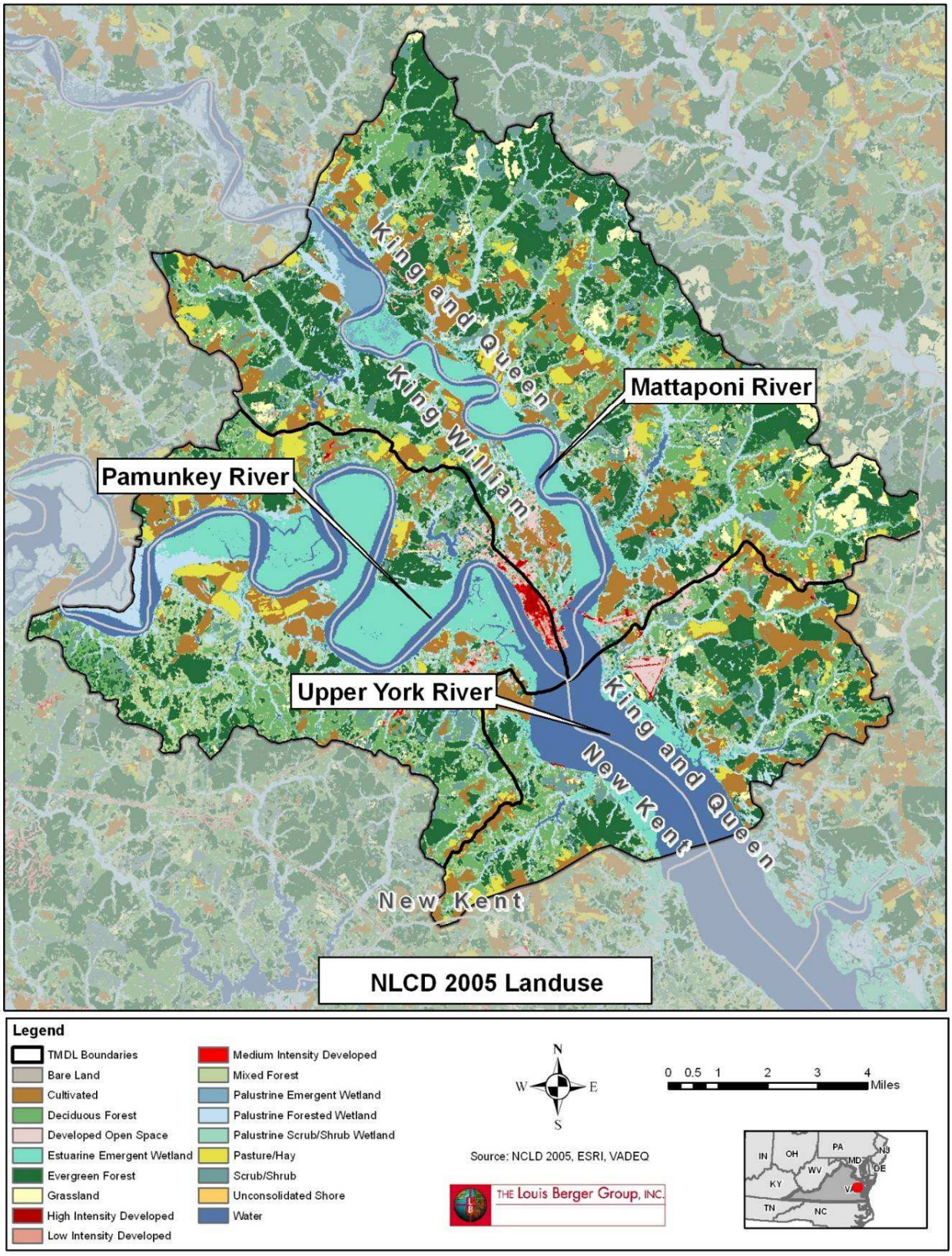

Figure 2-3: Land Use for the Upper Tidal York River watershed

2.3 Stream Flow and Estuary Volume Data

Stream Flow
There has been no stream flow monitored in the TMDL watersheds.

Estuary volume and tidal data
The estuary volume of the TMDL watersheds was provided by VA DEQ and is based on cross section measurements within the tidal portions of the TMDL watersheds. **Table 2-13** summarizes the results of provided volume data including average depth and surface area for the TMDL watershed. There is one station with available tide data located in the TMDL watershed. The tide data were retrieved from NOAA's Tides and Currents website and include mean tidal range, spring range, and mean tide level. **Table 2-14** shows the available tide data for this station.

Table 2-13: Volume Summary of the Upper Tidal York Watershed

Waterbody	Average Depth (m)	Surface Area (m^2)	Volume (m^3)
Upper York River (TMDL #1 & TMDL #2)	3.05	18,694,535	56,969,506
Lower Pamunkey River (TMDL #3)	3.45	11,313,069	39,068,362
Lower Mattaponi River (TMDL #4)	3.42	6,565,620	22,468,802

Table 2- 14: Existing NOAA Tide Station in the Upper York River TMDL Watershed

Name	Station ID	Location	Mean Tidal Range (feet)	Spring Range (feet)	Mean Tide Level (feet)
West Point, VA	8636769	Mattaponi River	2.8	3.4	1.5

2.4 Ambient Water Quality Data for Bacteria

Environmental monitoring efforts for collecting bacteria data in the TMDL watersheds have been conducted by the Virginia Department of Environmental Quality (VA DEQ) and the Virginia Department of Health-Department of Shellfish and Sanitation (VDH-DSS). VDH-DSS water quality data were provided from both VA DEQ and VDH-DSS. All available data for bacteria, located within the TMDL watersheds and at the boundary of the impaired watersheds, were analyzed and compared to VA DEQ bacteria standards for shellfish and recreation use. VDH-DSS only collected bacteria samples for the

indicator fecal coliform whereas VA DEQ for the indicator fecal coliform, Escherichia coli (E.coli), and enterococci. Bacteria samples for E. coli are not analyzed in this TMDL, because the indicator is used for waterbodies with fresh water and outside of the saltwater and transition zone. **Table 2-15** summarizes VDH-DSS and VA DEQ monitoring efforts for all bacteria indicators according to station ID. The location of the bacteria monitoring stations is depicted in **Figure 2-1**. The following sections summarize and present the available bacteria monitoring data within and at the boundaries of the TMDL watershed.

Table 2-15: Summary of VDH-DSS and VA DEQ Monitoring Stations, Stream, Bacteria Indicator, and Sample Date

Station ID	Stream	Indicator	Sample Date		Agency
			First	Last	
48-102	Upper York River	Fecal Coliform	1/10/1985	4/29/2009	VDH-DSS
49-103		Fecal Coliform	1/10/1985	4/29/2009	
49-104		Fecal Coliform	1/10/1985	4/29/2009	
49-104A		Fecal Coliform	1/10/1985	4/29/2009	
49-104B		Fecal Coliform	1/10/1985	4/29/2009	
49-105		Fecal Coliform	1/10/1985	4/29/2009	
49-106		Fecal Coliform	1/10/1985	4/29/2009	
49-107		Fecal Coliform	1/10/1985	4/29/2009	
49-204		Fecal Coliform	1/10/1985	4/29/2009	
49-205		Fecal Coliform	1/10/1985	4/29/2009	
49-206		Fecal Coliform	1/10/1985	4/29/2009	
49-207		Fecal Coliform	1/10/1985	4/29/2009	
50-200		Fecal Coliform	-	-	
50-202		Fecal Coliform	2/25/1985	4/29/2009	
50-203		Fecal Coliform	2/25/1985	4/29/2009	
8-MPN004.39	Mattaponi River	Fecal Coliform	2/14/1990	12/3/2007	VA DEQ
		Enterococci	7/6/2004	10/20/2009	
8-MPN017.46	Mattaponi River	Fecal Coliform	1/12/1994	11/13/2006	
		E. coli	1/12/1994	11/13/2006	
		Enterococci	10/23/2003	11/2/2009	
8-PMK034.17	Pamunkey River	Fecal Coliform	1/12/1994	12/3/2007	
		E. coli	7/6/2004	10/20/2009	
8-PMK006.36	Pamunkey River	Fecal Coliform	2/14/1990	10/29/2009	
		E. coli	7/9/2002	4/7/2004	
		Enterococci	7/9/2002	10/29/2009	
8-YRK031.39	York River	Fecal Coliform	11/12/1991	1/20/2010	
		Enterococci	7/9/2002	1/20/2010	
8-MCR001.64	Mill Creek	Fecal Coliform	9/25/1990	4/16/2001	

Table 2-15: Summary of VDH-DSS and VA DEQ Monitoring Stations, Stream, Bacteria Indicator, and Sample Date

Station ID	Stream	Indicator	Sample Date		Agency
			First	Last	
8-PHB001.40	Philbates Creek	Fecal Coliform	9/25/1990	4/16/2001	VA DEQ
8-TST003.16	Tastine Sw	E. coli	1/10/2008	12/22/2008	
8-TST001.81	Tastine Sw	Fecal Coliform	4/26/1995	3/13/2001	
		E. coli	1/10/2008	12/22/2008	
8-TST001.35	Tastine Sw	E. coli	1/10/2008	12/22/2008	
8-LTS001.65	Little Tastine Sw	E. coli	1/10/2008	12/22/2008	
8-XIN001.00	UT 1 Tastine Sw	E. coli	1/10/2008	12/22/2008	
8-XIO000.12	UT 2 Tastine Sw	E. coli	1/10/2008	12/22/2008	
8-CBN002.69	Corbin Pond	E. coli	1/10/2008	12/22/2008	
		Enterococci	1/10/2008	12/22/2008	
8-BMC003.65	Burnt Mill Creek	E. coli	6/6/2005	12/4/2006	
8-HTQ003.77	Heartquake Creek	E. coli	1/6/2009	11/2/2009	
		Fecal Coliform	4/26/1995	3/13/2001	

2.4.1 VA DEQ Bacteria Water Quality Data

VA DEQ collected samples for bacteria at sixteen water quality monitoring stations within and at the boundaries of the TMDL watershed. The location of the VA DEQ monitoring stations are shown in **Figure 2-2**. At VA DEQ stations where fecal coliform were collected, the geometric mean and 90th percentile for the bacteria indicator fecal coliform was computed based on the VDH-DSS approach, which calculates the geometric mean and 90th percentile values using the last 30 months of data (usually the last 30 collection events). The purpose of this analysis is to observe the impact of fecal coliform loads on shellfish impaired Upper York River. **Table 2-16** presents the maximum geometric mean and 90th percentile measurement for all observed samples and whether the shellfish water quality standard is exceeded. Bacteria data was also analyzed for enterococci and compared to the single sample maximum criterion. (Bacteria data could not be compared to the geometric mean criterion, since the required two samples per calendar month to calculate the geometric mean was not met.) **Table 2-17** presents a summary of VA DEQ enterococci exceedances and the maximum measurements for all observed samples and whether the recreational water quality standard is exceeded. Stations that did not have fecal coliform or enterococci data, or that did not have enough data to calculate the exceeded geometric mean and/or the exceeded 90th percentile are not

included in the tables. The results of the analysis for the entire fecal coliform data set are also shown in several figures in Appendix B.

Table 2-16: VA DEQ Maximum Values of Geometric Mean and 90th Percentile Exceedances for Fecal Coliform

Station ID	Segment	Geometric Mean	Station Exceeded Geometric Mean Standard: 14 MPN	90th Percentile	Station Exceeded 90th Percentile Standard: 49 MPN
8-PHB001.40	Philbates Creek	67	**Yes**	491	**Yes**
8-YRK022.70	York River	29	**Yes**	157	**Yes**
8-YRK028.10	York River	130	**Yes**	460	**Yes**
8-YRK031.39	York River	47	**Yes**	293	**Yes**
8-YRK031.48	York River	117	**Yes**	350	**Yes**

Table 2-17: Summary of VA DEQ Enterococci Exceedances

Station ID	Stream	No. of Samples	Exceedances		Maximum Value	Station Exceeded single sample maximum criterion: 104 MPN*
			No.	%	No/100ML	
8-MPN004.39	Mattaponi River	63	21	33	1500	**Yes**
8-MPN017.46	Mattaponi River	16	5	31	380	**Yes**
8-PMK006.36	Pamunkey River	79	35	44	2000	**Yes**
8-YRK022.70	York River	82	4	5	1100	**No**
8-YRK031.39	York River	83	21	25	>2000	**Yes**
8-CBN002.69	Corbin Pond	9	0	0	100	**No**

*When violation rate of 10% is exceeded

2.4.2 VDH-DSS Bacteria Water Quality Data

VDH-DSS conducted sampling for fecal coliform at 14 of their 15 monitoring stations within the Upper Tidal York watershed. All 14 stations are located on the mainstem of the Upper York River. The analysis of the fecal coliform data is based on the VDH-DSS approach, which calculates the geometric mean and 90th percentile values using the last 30 months of data (usually the last 30 collection events). All available fecal coliform data were analyzed from 1985 through the present to calculate the geometric mean and 90th percentile values. The computed geometric mean and 90th percentile values were then compared to the VA DEQ water quality criteria for shellfish waters. The results of this analysis are shown in **Table 2-18**, which summarize the maximum geometric mean

and 90th percentile measurements of the entire data set. The maximum value is shown in order to include the worst case condemnation. Stations that did not have enough data to calculate the exceeded geometric mean and/or the exceeded 90th percentile are not included in the table (Station 50-200). The results of the analysis for the entire fecal coliform data set are also shown in several figures in Appendix B.

Table 2-18: VDH-DSS Maximum Values of Geometric Mean and 90th Percentile Exceedances per Station

Segment	Station ID	Geometric Mean	Station Exceeds Geometric Mean Criterion: 14 MPN	90th Percentile	Station Exceeds 90th Percentile Criterion: 49 MPN
Upper York River	48-102	16	**Yes**	90	**Yes**
	49-103	22	**Yes**	115	**Yes**
	49-104	21	**Yes**	93	**Yes**
	49-104A	37	**Yes**	236	**Yes**
	49-104B	67	**Yes**	468	**Yes**
	49-105	22	**Yes**	115	**Yes**
	49-106	28	**Yes**	154	**Yes**
	49-107	35	**Yes**	205	**Yes**
	49-204	20	**Yes**	101	**Yes**
	49-205	24	**Yes**	169	**Yes**
	49-206	25	**Yes**	150	**Yes**
	49-207	30	**Yes**	175	**Yes**
	50-202	18	**Yes**	99	**Yes**
	50-203	16	**Yes**	96	**Yes**

2.4.3 VDH-DSS Bacteria Source Data

As part of the TMDL development, Bacteria Source Tracking (BST) sampling was conducted by VDH-DSS over a twelve-month period from October 2005 to September 2006 at one VDH-DSS monitoring station, 49-207 (**Figure 2-1**). The objective of the BST study was to identify the sources of bacteria contamination within the Upper Tidal York watershed. The BST analysis was performed by MapTech (Map Tech, Inc., Dec. 2006).

There are various methodologies used to perform BST, which fall into three major categories: molecular, biochemical and chemical. Molecular (genotype) methods are referred to as “DNA fingerprinting,” and are based on the unique genetic makeup of

different strains, or subspecies, of bacteria. Biochemical (phenotype) methods are based on detecting biochemical substances produced by bacteria. The type and quantity of these substances are measured to identify the bacteria source. Chemical methods are based on testing for chemical compounds that are associated with human wastewaters, and are restricted to determining if sources of pollution are human or non-human.

The Antibiotic Resistance Analysis (ARA) method, a biochemical method, was used for the Upper York River. ARA has been the most widely used and published BST method to date and has been employed in Virginia, Florida, Kansas, Oregon, South Carolina, Tennessee, and Texas. Advantages of ARA include low cost per sample and fast turnaround times for analyzing samples. The method can also be performed on large numbers of bacterial isolates. For the Upper Tidal York River watershed, the maximum number of bacterial isolates per sample is 24.

Overall, the results from BST indicate that bacteria from human, livestock, wildlife, and pet sources are present in the Upper York River. Results from all sampling events at the monitoring stations are presented in **Table 2-19** and **Appendix C**.

Table 2-19: BST Sampling Events within the Upper Tidal York River watershed

Station	Date	Fecal Coliform (counts/100mL)*	Isolates	Wildlife	Human	Livestock	Pets
Upper York River, Station 49-207	10/12/05	43	24	8%	**63%**	17%	**12%**
	11/28/05	43	8	25%	25%	50%	0%
	12/12/05	23	22	**63%**	5%	14%	**18%**
	1/9/06	9.1	4	75%	25%	0%	0%
	2/22/06	7.3	4	25%	0%	50%	25%
	3/8/06	3.6	NVI	NVI	NVI	NVI	NVI
	4/5/06	9.1	NVI	NVI	NVI	NVI	NVI
	5/23/06	3	6	67%	0%	0%	33%
	6/20/06	43	15	**20%**	13%	**47%**	**20%**
	7/5/06	1100	24	**71%**	8%	17%	4%
	8/2/06	93	24	8%	**29%**	12%	**51%**
	9/14/06	240	24	12%	**17%**	**46%**	**25%**

NVI: No viable isolates.

* Since no E. coli data was available (BST is cultured the indicator E. coli) the enumerations are based on VDH-DSS fecal coliform data collected on the same day as the BST data.

2.4.3.1 Weighted Average of BST Sources

In order to eliminate some of the high variability in BST results, a method was developed by VA DEQ, which computes a weighted average based on the fraction of each bacteria source (wildlife, human, livestock, and pets). The weighted average for each source is calculated by dividing the total number of biochemical responses to antibiotics of each source (wildlife, human, livestock, or pet) with the total number of responses to antibiotics from all sources (the sum of all the sources). The total number of biochemical responses to antibiotics for each source for each sample is obtained by multiplying the total number of isolates with the bacterial enumeration (Fecal coliform in MPN/100mL) and with the fraction of the source.

The weighted average of each source represents the fraction of bacterial source in the watershed and is applied in this bacterial TMDL in order to allocate nonpoint sources of bacteria. **Table 2-20** and **Figure 2-4** depict the computed weighted average for each station. **Figure 2-4** depicts the BST at monitoring station 49-207.

Table 2-20: Computed Weighted BST Fractions

Segment	Station	Wildlife	Human	Livestock	Pets
Upper York River (TMDL #1 & TMDL #2)	49-207	55%	12%	22%	11%

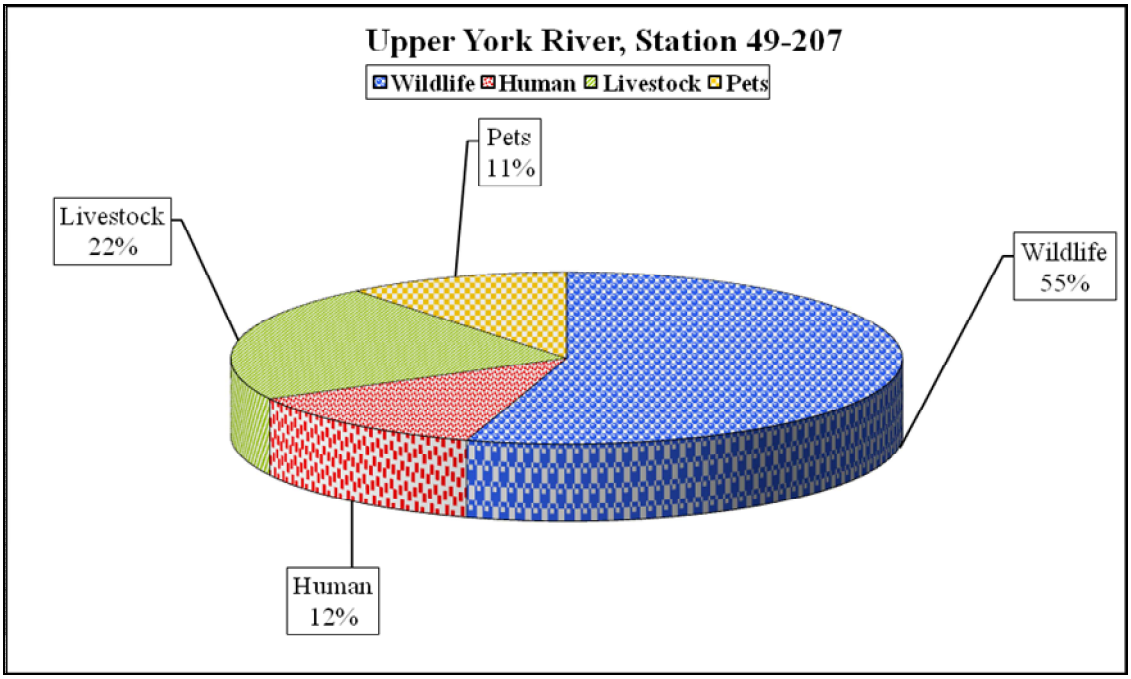

Figure 2- 4: Weighted BST Results at Station 49-207 (Upper York River)

2.4.4 VDH-DSS Shoreline Sanitary Survey Data

The shoreline survey is used as a tool to identify nonpoint source contribution to bacteria problems. VDH-DSS surveyed the Upper Tidal York River watershed in 2005. Included in this shoreline survey was the York River: West Point Vicinity, including the counties of King and Queen, King William, and New Kent. The results of the shoreline survey can be found in Appendix A.

2.5 Bacteria Source Assessment

This section focuses on characterizing the sources that potentially contribute to the bacteria loading in the TMDL watershed. These sources include permitted facilities, septic systems, livestock, biosolids, wildlife, and pets.

Based on data obtained from VA DEQ, there are several individually permitted facilities including general permits within the bacteria impaired watershed. There are no known MS4 permits within the watershed. Bacteria source data has been obtained from published sources as well as citizen feedback and involvement.

2.5.1 Permitted Facilities

Based on data obtained from VA DEQ, there are several permitted facilities in the Upper Tidal York River watershed. The permit number, permit type, facility name and receiving stream for each permit are presented in **Table 2-21**. The available flow data for those facilities permitted to discharge bacteria were analyzed and compared to their permit bacteria limit. The fecal coliform maximum concentration exceeded the bacteria limit 27 times at HRSD Town of West Point Sewage Treatment Plant (VA0075434). The immediate area downstream of HRSD Town of West Point is identified by DSS as a shellfish prohibited area. The direct harvest of shellfish for human consumption is prohibited because of the location of a municipal wastewater treatment plant in this segment.

The locations of the permitted facilities are presented in **Figure 2-5.** Latitudes and longitudes were not available for several permits (asterisked in Table 2-21). Facilities permitted to discharge bacteria are shown in **Figure 2-5**.

Table 2-21: Permitted Facilities in the Upper Tidal York River watershed			
Permit Number	**Type**	**Facility Name**	**Receiving Stream**
VA0003115	VPDES	Rock-Tenn West Point Mill	Pamunkey River
[1]VA0075434	VPDES	HRSD Town of West Point Sewage Treatment Plant	Mattaponi River
[1]VA0088331	VPDES	Parham Landing WWTP	Pamunkey River
VA0090433	VPDES	Augusta Lumber LLC - West Point Division	UT Herrick Creek
[1]VAG404212	Domestic	Residence	UT Olsson's Pond
VAG840139	NMMM	Britts Inc Mine 1	Thorofare Creek
VAG110189	Ready Mix	Rappahannock Concrete - New Kent	UT Mill Creek
VAR051194*	Stormwater - Industrial	Bohannon Lumber Company Inc	Glebe Swamp
VAR051243	Stormwater - Industrial	Commercial Carrier Corporation	Mill Creek
VAR051263	Stormwater - Industrial	Direct Wood Products Plant 1	Eltham Creek
VAR051596	Stormwater - Industrial	Basic Construction Company -New Kent Asphalt Plant	UT Pamunkey
VAR051609	Stormwater - Industrial	Middle Peninsula Regional Airport	Goalders Creek
VAR051378	Stormwater - Industrial	Asb Greenworld Incorporated	Goalders Creek
VAR100200*	Stormwater - Construction	VDOT Richmond District 0634 063 P42 M501	Taylor Pond
VAR102161*	Stormwater - Construction	Stainback - Residence	Goose Creek
VAR103065*	Stormwater - Construction	West Point Station	Glass Island Creek
VAR103207*	Stormwater - Construction	Crouse James F and Reginia – Residence	Taylor Pond
VAR103856*	Stormwater - Construction	Independent Group - Bohannon Industrial Park	Glebe Swamp
VAR102402	Stormwater	Mann Hill Farm	Custis Mill Creek
VAR102640*	Stormwater - Construction	George Nice and Sons Inc	UT to France Swamp
VAR102650*	Stormwater -	Twin Island Farms	York River

Table 2-21: Permitted Facilities in the Upper Tidal York River watershed			
Permit Number	**Type**	**Facility Name**	**Receiving Stream**
	Construction		
VAR103062*	Stormwater - Construction	Lacy David V Residence	Hockley Creek/UT
VAR104561*	Stormwater - Construction	Shores of the York	York River
VAR104937*	Stormwater – Construction	Middle Peninsula Regional Airport	Goalders Creek
[1]Facility permitted to discharge bacteria			
UT: Unknown tributary			
* These permits do not have latitude and longitude data and do not appear in Figure 2-5.			

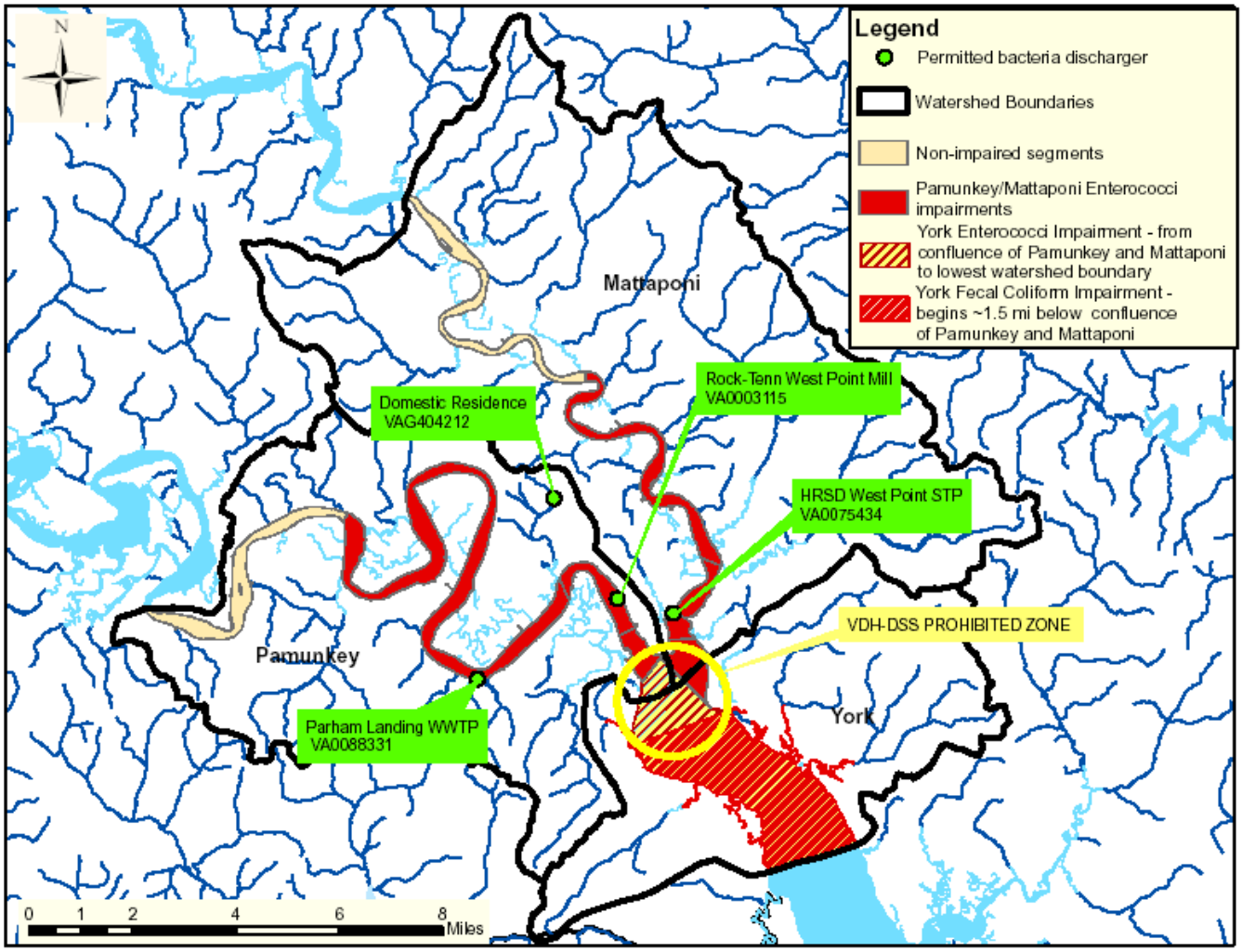

Figure 2-5: Individual VPDES permitted facilities in the watershed

2.5.2 Sanitary Sewer System, Septic Tanks, and Straight Pipes

Houses can be connected to a public sanitary sewer, a septic tank, or the sewage can be disposed by other means. Estimates of the total number of households using each type of waste disposal are presented in this section.

The 2000 U.S. Census Bureau census track data for King and Queen, King William, and New Kent counties were reviewed to establish the population growth rates and number of housing units in the watershed. 2008 estimates were used for the total population estimate, and for the number of houses. The 1990 census data documents the distribution of houses on sewage systems, septic systems, and other means (considered to be straight pipes). These 1990 estimated distributions were applied to the 2008 population and housing unit numbers by assuming the distributions in 1990 and 2008 are the same and multiplying the total number of houses in 2008 by the percent distributions in 1990 to estimate the number of houses on public sewers, septic tanks and other means in 2008. A summary of the census data and population estimates used for the TMDL watershed are presented in **Table 2-22**.

In order to determine the amount of bacteria contributed by human sources, it is necessary to estimate the failure rates of septic systems. The number of failing septic systems in each watershed was based on the US Census data. The number of households in each watershed were determined from US Census Bureau data and then multiplied by the septic failure rate of 12% (VA DEQ, 2005). The 12% septic failure rate is a default value when Virginia Department of Health (VDH) information regarding septic failure rates in the watershed is unavailable. **Table 2-22** also shows the estimated amount of failing septic systems per county. **Table 2-23** shows the estimated amount of population, number of houses, number of houses on public sewer, number of houses on septic systems, number of houses on other means, and number of failing septic systems per TMDL watershed.

Table 2-22: Population Estimates for King and Queen, King William and New Kent Counties						
County/Town	**Population[1]**	**Number of Houses[1]**	**Number of Houses Public Sewer [1], [2]**	**Number of Houses on Septic Systems [1], [2]**	**Number of Houses on "Other Means" [1], [2]**	**Number of Houses with a Failing Septic System[3]**
King and Queen	6,830	3,355	17	3,114	224	374
King William[4] (Including Town of West Point)	16,040	6,452	1,788	4,349	315	522
New Kent	17,825	7,111	73	6,875	163	825
TOTAL	**40,695**	**16,918**	**1,878**	**14,338**	**702**	**1,721**

[1] Census 2008 estimates

[2] Based upon 2008 census estimate and ratio of parameter: 1990 census estimate

[3] Based on a septic failure rate of 12% (VA DEQ 2005)

[4] Town of West Point numbers are as follows: Population: 2,866; Number of Houses: 1,490; Number of Houses Public Sewer: 1,388; Number of Houses on Septic Systems: 102; Number of Houses on "Other Means": 0; Number of Houses with a Failing Septic System: 12. Population is based on Census 2000 estimates, Number of Houses numbers were provided by the Town of West Point, and the Number of Failing Septic Systems was calculated using a septic failure rate of 12%.

Table 2-23: Population Estimates per TMDL Watershed						
TMDL Watershed	**Population [1]**	**Number of Houses[1]**	**Number of Houses Public Sewer[2]**	**Number of Houses on Septic Systems[2]**	**Number of Houses on "Other Means"[2]**	**Number of Houses with a Failing Septic System[3]**
TMDL #1 and #2 Upper York Shellfish and Recreational	7,281	3,064	277	2,657	130	319
TMDL #3 Lower Pamunkey	3,691	1,476	128	1,303	45	156
TMDL #4 Lower Mattaponi	2,523	1,127	145	916	66	110
TOTAL	**13,495**	**5,667**	**550**	**4,876**	**241**	**585**

[1] Census 2008 estimates

[2] Based upon 2008 census estimate and ratio of parameter: 1990 census estimate

[3] Based on a septic failure rate of 12% (VA DEQ 2005)

2.5.3 Livestock

An inventory of the livestock of the Upper Tidal York River watershed was conducted using data and information provided by United States Department of Agriculture (USDA)

Census of Agriculture (2007)[1], and stakeholders input. Livestock information was available for all counties in the watershed. This database was used to determine the livestock inventories shown in **Table 2-24** per county**.** **Table 2-25** shows estimates of livestock inventories per TMDL watershed.

Table 2-24: Livestock Present in King and Queen, King William and New Kent Counties

County/Town	Cattle	Pigs	Poultry	Horses	Sheep
King and Queen	1,418	N/A	151	306	84
King William (Including Town of West Point[1])	1,781	440	467	254	68
New Kent	663	20	689	404	63
TOTAL	**3,862**	**460**	**1,307**	**964**	**215**

Differences in totals are due to rounding;
[1] Town of West Point numbers are as follows: Cattle: 0; Pigs: 0; Poultry: 0; Horses: 0; Sheep: 0
Numbers were provided by the Town of West Point.

Table 2- 25: Livestock Present Per TMDL Watershed

TMDL Watershed	Cattle	Pigs	Poultry	Horses	Sheep
TMDL #1 and #2 Upper York Shellfish and Recreational	721	67	232	185	42
TMDL #3 Lower Pamunkey	222	21	72	57	13
TMDL #4 Lower Mattaponi	353	33	114	91	20
TOTAL	**1,296**	**121**	**418**	**333**	**75**

2.5.4 Land Application of Biosolids

Biosolids applications can adversely impact bacteria levels if not tilled into the soil prior to the next significant rain. Biosolids are typically lime stabilized by the source or the applicator prior to application by mixing lime into the material to raise the pH to pH 12, which kills the bacteria. However Class B biosolids, the type typically applied in Virginia, are allowed to contain up to 1,995,262 cfu/g-dry fecal bacteria. VA DEQ makes a thorough search for biosolids permit applications for the location of potential

[1] Data available from the USDA 2007 Census of Agriculture Report for the state of Virginia at http://www.agcensus.usda.gov/Publications/2007/Full_Report/index.asp

application fields in a TMDL watershed, and then requests dates of applications and tonnage applied from applicators.

Based on data provided by Virginia Department of Health (VDH) and VA DEQ indicated that there have been biosolid applications in the counties of King and Queen, New Kent, and King William between 2000 and 2006; No biosolid applications were recorded for the area within the boundaries of the Town of West Point. Biosolid data were available in dry tons and total area of application except for the County of New Kent where only the area of application was available. **Table 2-26** gives a summary of the dry tons applied per county per year. Note that only application sites, where geographic coordinates were available, are presented in the table. **Table 2-27** presents the available biosolid information per TMDL watershed.

Table 2-26: Biosolid Application by County (dry ton/year)

County	2000	2001	2002	2003	2004	2005	2006
King & Queen	1,946	6,186	1,565	-	7,734	6,929	1,037
King William	5,829	10,744	-	-	-	-	-
New Kent*	-	-	-	-	-	-	-

*No Biosolids loads were available for New Kent
Note that only application sites, where geographic coordinates were available, are presented in the table.

Table 2- 27: Biosolid Application by Impaired Segment Watershed (dry ton/year)

Impaired Segment Watershed*	2000	2001	2002	2003	2004	2005	2006
TMDL #1 and #2 Upper York River	-	-	-	-	270	44	-
TMDL #3 Lower Pamunkey River	-	-	-	-	-	-	-
TMDL #4 Mattaponi River	-	274	-	-	421	234	121

* Note that only application sites, where geographic coordinates were available, are presented in the table.

2.5.5 Wildlife

Similar to livestock contributions, wildlife contributions of bacteria can be indirect or direct. Indirect sources are those that are carried to the stream from the surrounding land via rain and runoff events, whereas direct sources are those that are directly deposited into the stream.

The wildlife inventory for the TMDL watershed was developed based on numbers provided by the Department of Game and Inland Fisheries (DGIF). The number of wildlife in the watershed was estimated by combining typical wildlife densities with available stream wildlife habitat. Typical wildlife densities provided by DGIF are presented in **Table-2-28**. Information from these databases was used to determine the wildlife inventory for each county as shown in **Table 2-29**, and per TMDL watershed as shown in **Table 2-30.**

Table 2- 28: Wildlife Densities in the TMDL Watersheds[1]

Wildlife type	Population Density	Habitat Requirements
Deer	0.047 animals/acre	Entire watershed
Raccoon (low density)	10/square mile	Upland forest
Raccoon (high density)	50/square mile	Bottomland forest, marsh, swamp, along streams
Muskrat (low density)	2 animals/mile	16/mile of ditch or medium sized stream intersecting agriculture crop fields, 8/mi of medium sized stream intersecting pasture fields, 10/mi of pond or lake edge, 50/mi of slow-moving river
Muskrat (high density)	15 animals/mile	
Muskrat (average density)	10 animals/mile	
Beaver (low density)	1.0/mile	Permanent streams and rivers
Beaver (high density)	14.5/mile	
Beaver (average density)	4.8/mile	
Canada Goose	http://migbirdapps.fws.gov/	Based on particular strata for watershed area
Mallard		
Wood Duck		
Black Duck		

[1] Source: Department of Game and Inland Fisheries (DGIF)

Table 2-29: Wildlife Present in King and Queen, King William and New Kent Counties

County/Town	Acres	Canada Geese	Black Duck	Wood Duck	Mallard	Deer	Raccoon	Muskrat	Beaver
King and Queen	205,229	284	0	0	284	9,646	6,721	5,147	975
King William (Including Town of West Point[1])	182,562	415	0	0	415	8,580	6,809	5,019	951
New Kent	140,575	369	0	0	369	6,607	5,901	3,735	709
TOTAL	**528,366**	**1,068**	**0**	**0**	**1,068**	**24,833**	**19,431**	**13,901**	**2,635**

[1]Town of West Point Numbers are as follows: Acres: 4,259; Canadian Geese: 10; Black Duck: 0; Wood Duck: 0; Mallard: 10; Deer: 200; Raccoon: 159; Muskrat: 117; Beaver: 22

Table 2- 30: Wildlife Present Per TMDL Watershed[1]									
TMDL Watershed	**Acres**	**Canada Geese**	**Wood Duck**	**Black Duck**	**Mallard**	**Deer**	**Raccoon**	**Muskrat**	**Beaver**
TMDL #1 and #2 Upper York Shellfish and Recreational	106,392	>2,206	0	0	206	4,781	4,152	3,021	572
TMDL #3 Lower Pamunkey	32,793	>1,000[2]	0	0	63	1,474	1,280	931	176
TMDL #4 Lower Mattaponi	52,138	>1,000[2]	0	0	101	2,343	2,035	1,480	280

[1] Based on the Department of Game and Inland Fisheries (DGIF)
[2] Based on stakeholders' input

2.5.6 Pets

The two types of domestic pets that were considered potential bacteria sources in this watershed were cats and dogs. The Animal Control Office (ACO) of the three counties was contacted to request information on total dog numbers (individual and kennels) and the location of kennels. The information provided by the counties is summarized in **Table 2-31.** 20-kennel and 50-kennel licenses indicate that up to 20 or 50 dogs respectively can be accounted for by each tag. The numbers shown in Table 2-31 for these categories reflect the maximum number of dogs possible. In order to estimate the number of pets in the counties where no information was provided, pet numbers were estimated by determining the number of households in the county and multiplying this number by national average estimates of the number of pets per household, which are 0.543 dogs per household and 0.593 cats per household (American Veterinary Medical Association). **Table 2-32** shows the numbers of dogs and cats within each county based on estimates and the provided number of individual dog counts from the counties. **Table 2-33** shows the number of pets per TMDL watershed based on household numbers. Information from the ACO on dogs was not used in Table 2-33, since no information on the graphical location of ACO dog numbers was provided.

Table 2- 31: Dogs Present for King and Queen, King William and New Kent Counties				
County	**Tag Type**	**2007**	**2008**	**2009**
King and Queen	Individual	NI	NI	NI
	20-kennel*	NI	NI	NI
	50-kennel*	NI	NI	NI
King William	Individual	NI	NI	4,300**
	20-kennel*	NI	NI	3,500
	50-kennel*	NI	NI	NI
New Kent	Individual	1,978	2,921	3,203
	20-kennel*	2,920	2,620	2,800
	50-kennel*	950	800	950
			New Kent Total:	6,953

*The numbers presented reflect the maximum amount of dogs possible
**Number has been doubled due to estimation by King William County Department of Treasury
NI = No information;

Table 2- 32: Pet Inventory for King and Queen, King William and New Kent Counties			
County	**Households**	**Dogs[2]**	**Cats**
King and Queen	3,355	1,822	1,990
King William (Including Town of West Point[1])	6,452	4,300	3,826
New Kent	7,112	3,203	4,217
TOTAL	**16,919**	**9,325**	**10,033**

[1] Town of West Point numbers are as follows: Households: 1,490; Dogs: 809; Cats: 884. Number of Households provided by the Town of West Point.
[2]The total number of dogs in King William and New Kent County are based on individual counts in 2009 from ACO; no information was available for dog counts in King and Queen County. The dog numbers do not include dog numbers from kennels, since they represent maximum numbers of dogs possible. Dog numbers in King William and New Kent Counties including kennels from 2009:
King William: 4,300 (individual) + 3,500 (kennels) = 7,800
New Kent: 3,203 (individual) + 6,953 (kennels) = 10,156

Table 2- 33: Pet Inventory per TMDL Watershed			
TMDL Watershed	**Households**	**Dogs**	**Cats**
TMDL #1 and #2 Upper York Shellfish and Recreational	3,064	1,664	1,817
TMDL #3 Lower Pamukney	1,476	802	875
TMDL #4 Lower Mattaponi	1,127	612	668
TOTAL	**5,667**	**3,078**	**3,360**

Number of households provided by King and Queen, King William and New Kent Counties
Source: American Veterinary Medical Association (AVMA); 0.593 cats/household, 0.543 dogs/household